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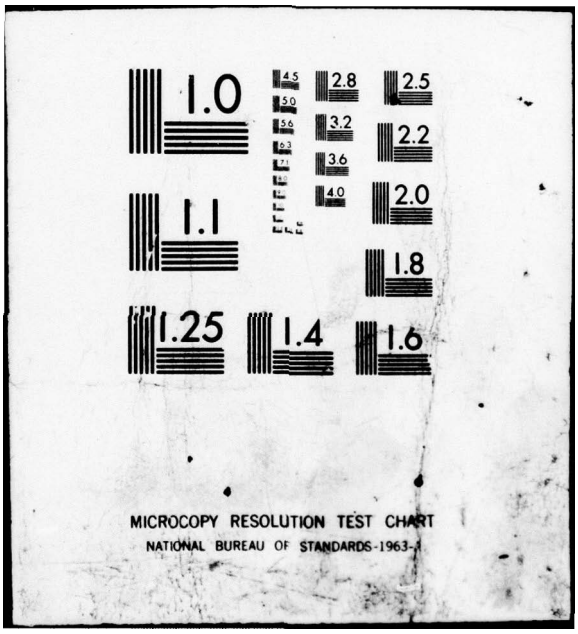
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ANIMAL EXPERIMENTS AT FOA SHOW THAT MICROWAVES HAVE BOTH PHYSICAL AND PSYCHOLOGICAL EFFECTS

(Mikrovagor Paverkar bade Fysiskt Och Psykiskt)

Increased use of microwaves may involve risks. Animal experiments show that they affect respiration, heart and pulse rate, brain functions, hormone secretion and blood formation.

Apr 79

12 p.

Ulf Olsson

Transl. of FOA Tidningen ~~A6, 2 (1978) 7-9~~ (Sweden) v16 n3 p7-9 1978, by R. E. Williams.

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Microwaves are used in an increasing number of ways; apart from in radio and radar systems, they are used, for example, in microwave ovens, in welding and wood bonding, in medical equipment for heat treatment and burn surgery, in police speed checks and in burglar alarms. Frequencies vary between 1000 and 10,000 MHz, although many pieces of equipment operate at a frequency of 2450 MHz, and the power varies between 1 kW and approx. 2 MW.

Before one can calculate the total dose of radiation to which a person can be exposed from a piece of equipment, details are needed on rate of dose or intensity, wavelengths or frequency and duration of radiation. The power is expressed in W/m^2 or mW/cm^2. The radiation intensity can be divided into that which has a thermal effect and that which does not. The threshold is usually set at 10 mW/cm^2.

In Sweden the permitted intensity is only 1mW/cm^2, in the Soviet Union it is even lower at 0.1 mW/cm^2, and in the USA it is 10 mW/cm^2.

What damage may be caused?

In animal experiments microwave radiation affected respiration, heart and pulse rate and the functions of the cerebral cortex. Microwave radiation can also cause hormone changes, e.g. increased secretion of gastric juices and bile, and it has also been found to have an effect on blood-forming organs.

The cardiac rhythm of frogs has been affected by pulsed waves with average intensities as low as 0.0006 mW/cm^2. Other effects are an increase in blood pressure and a reduction in the number of cells which react to sound and pain stimuli. The reaction of the pupils is also influenced. Disorders may be intensified if, for example, antenna effects are produced in blood vessels and nerve paths.

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By using microwave radiation, a geneticist has produced changes in eye colour in fruit flies, indicating changes in the genotype.

FOA studies

In order to study how microwave radiation affects biological material, investigations were carried out on mice in the Biological Environment Section of FOA. Olle Criborn, who was responsible for the investigations, reports that the effect of microwaves on male mice was studied in two series of experiments, below and above the threshold for thermal effects. The parameters studied were body weight, body temperature, respiration, activity, ability to learn and sensory reaction.

The equipment used in the investigations included the apparatus for recording respiration and reaction to tones designed by Olle Criborn, which was described in Foatidningen 3/1974. Principally it consists of an enclosed plexiglass respiration chamber and an audio-frequency oscillator. The apparatus was then placed in a radiation cabinet, with an internal covering of microwave absorbing material, in order to minimize disturbance to wave propagation.

The radiation was provided by a microwave generator, producing waves at a frequency of 2450 MHz. A high voltage unit powers a magnetron connected to a S-band waveguide with a waveguide opening in the radiation cabinet.

In order to obtain radiation intensities of 100, 10 and 1 mW/cm^2, the experimental animals were placed at varying distances from the waveguide outlet in the cabinet.

Recording of respiration and tone reaction

The experimental animal was placed in the respiration chamber so that respiration activity (volume per minute) could be recorded. The chamber, which has a Teflon base, was connected to a sensitive pressure transducer. In the cover of the container there is a miniature loudspeaker, which was connected to the audio-frequency oscillator. This produces 12 two-second tone pulses per minute at a frequency of 8 kHz. Under normal conditions, the respiratory activity of the mice increases with the tone pulses. This conditioned sensory reaction is known as tone reaction.

Wheel activity

The amount of time spent by mice running in their wheels was used as a measure of the activity generated, since it has been found that running speed varies comparatively little between mice of the same age.

Temperature, weight and haemoglobin content

The body temperature was measured with a thermistor thermometer. The mice were weighed every morning between 7 and 8 o'clock. At the beginning of the investigation the animals, male mice bred by FOA, were about 17 days old and weighed between 24 and 29 grammes. Photometry was used to measure the haemoglobin content in blood taken from the tails of the mice.

Pilot test - 6 minutes irradiation

In order to investigate how sensitive mice are to microwaves at an intensity of 100 mW/cm^2, we studied the effect of the microwaves on respiration, tone reaction and body temperature during and after irradiation.The animals were accustomed to being in the respiration chamber with the tone pulses over a period of 3 days before this test was carried out.

When the irradiation began,the respiratory minute-volume dropped in the first mouse,without any change in the tone reaction. After 1 minute's irradiation, the tone reaction worsened and was totally absent after a further 20 seconds. After 2 minutes, the respiratory minute-volume increased and afterwards fluctuated considerably. After 5 minutes and 30 seconds, the respiratory minute-volume started to fall, and when the radiation was ended after 6 minutes, the mouse was dead. Its body temperature at that time was 42.2°C. However, one mouse, which followed a similar course under irradiation, had a body temperature of 43°C.

Two of the mice survived the irradiation.They had retained an increased respiratory minute volume during the final stage of the radiation. Their temperatures were 41.8°C and 39.7°C. One of the mice had a high respiratory minute-volume and an irregular tone reaction before it was subjected to the irradiation. Its tone reaction disappeared after only 20 seconds and its respiratory minute-volume increased after about 1 minute. After 4 minutes 20 seconds, the high and irregular minute-volume decreased rapidly. The irradiation was then interrupted immediately and the temperature was found to be 39.8°C.

This test shows the limit of what a mouse can endure at a radiation intensity of 100 mW/cm^2.

In the mice which survived the radiation, tone reaction returned quickly and after 1 hour it was almost normal again. Both respiratory activity and body temperature slowly returned to their normal values during the next 6 hours after the irradiation.

The conclusion which can be drawn from the test is that 100 mW/cm^2 for 6 minutes can be a lethal dose. For this reason the duration of irradiation was reduced to 3 minutes in the tests which followed.

Three minutes radiation

In the tests which followed, with irradiation lasting 3 minutes, the initial stage showed results largely in agreement with those of the pilot test. After about 1 minute, the tone reaction disappeared and after another 30 seconds respiratory activity increased rapidly. This increase continued until the radiation was stopped (see Fig. on Page 8). Recovery after the shortest period of radiation naturally occurred even more quickly than in the pilot test. Tone reaction returned after only 20 minutes, but it was lower than that of the control animals for the whole of the first 24 hours. Both respiration and body temperature returned to their normal values after 2 hours, and were normal for the next 3 days.

For the first 5 days after the test, there were no major differences in the amount of time spent in running by those animals which had been subjected to radiation and those which had not. However, on the 6th night the irradiated animals ran for a shorter time than the control group. The number of running periods also began to fall. However, the running time was normalized at 17 days and the periods of running 21 days after the irradiation.

The haemoglobin value was normal for the first few days after the irradiation. However, it decreased together with activity on the wheel in the case of the irradiated animals, and did not return to the same level as in the control group until the 21st day, when activity on the wheel also returned to normal. Presumably, decrease in activity on the wheel is associated with damage to the blood-forming organs. In man, corresponding effects would only appear after 30 days.

Tests at 10 mW/cm^2

Tests were also carried out on mice at a dose intensity of 10 mW/cm^2. In order to relate the tests to those carried out earlier, the duration of irradiation was increased to 30 minutes, so that the dose was 300 mW/cm^2 in both cases.

The test showed that the respiratory minute-volume first decreases, both at 100 mW/cm^2 and at 10 mW/cm^2. However, at an intensity of 100 mW/cm^2 the mouse loses its ability to regulate heat after 2 minutes, leading to an increase in body temperature. On the other hand, at 10 mW/cm^2 the increase in temperature is counteracted throughout the period of irradiation by a decrease in the respiratory minute-volume. After 15 minutes, there is a clear decrease which continues throughout the period of irradiation, indicating that the animals are exposed to thermal effects without an increase in body temperature. The microwave energy absorbed by the mouse is converted into heat, and consequently the

heat regulating mechanism reduces the oxygen intake, as is clear from the fact that respiration activity decreases. However, respiration begins to become normal again only 15 minutes after the end of irradiation.

Tone reaction decreases both at 100 and at 10 mW/cm^2. At 10 mW/cm^2 it is lost after 15 minutes, although not in all experimental animals. Where tone reaction is lost, it begins to return about 15 minutes after the end of irradiation.

The fact that respiration and tone reaction are affected at a radiation intensity of only 10 mW/cm^2 should be of interest, when it is considered that this radiation intensity is permitted, e.g. in the USA. The FOA results are in close agreement with those obtained by foreign researchers. In the Soviet Union, for example, it has been found that microwaves with an intensity between 1 and 10 mW/cm^2 can cause damage to conditioned reflexes and induce abnormal behaviour patterns.

The special antenna effects which may be produced during irradiation, however, are of particular interest. Conductive electrolyte in nerve cells for example can considerably increase the potential difference across certain nerve membranes and in the same way an increased potential difference may be produced at interneuroral synopsis. Here the nerve pulse is affected in various ways, e.g. by being propagated or blocked.

In addition, blood vessels may be considered to act as magnetic dipole antennae which produce large potential differences across various organs. In this way the microwave radiation entering may be increased so that the permitted radiation intensities of 1 mW/cm^2 can rise locally to 100 mW/cm^2. For this reason Olle Criborn believes that the effects of microwaves should be examined carefully.

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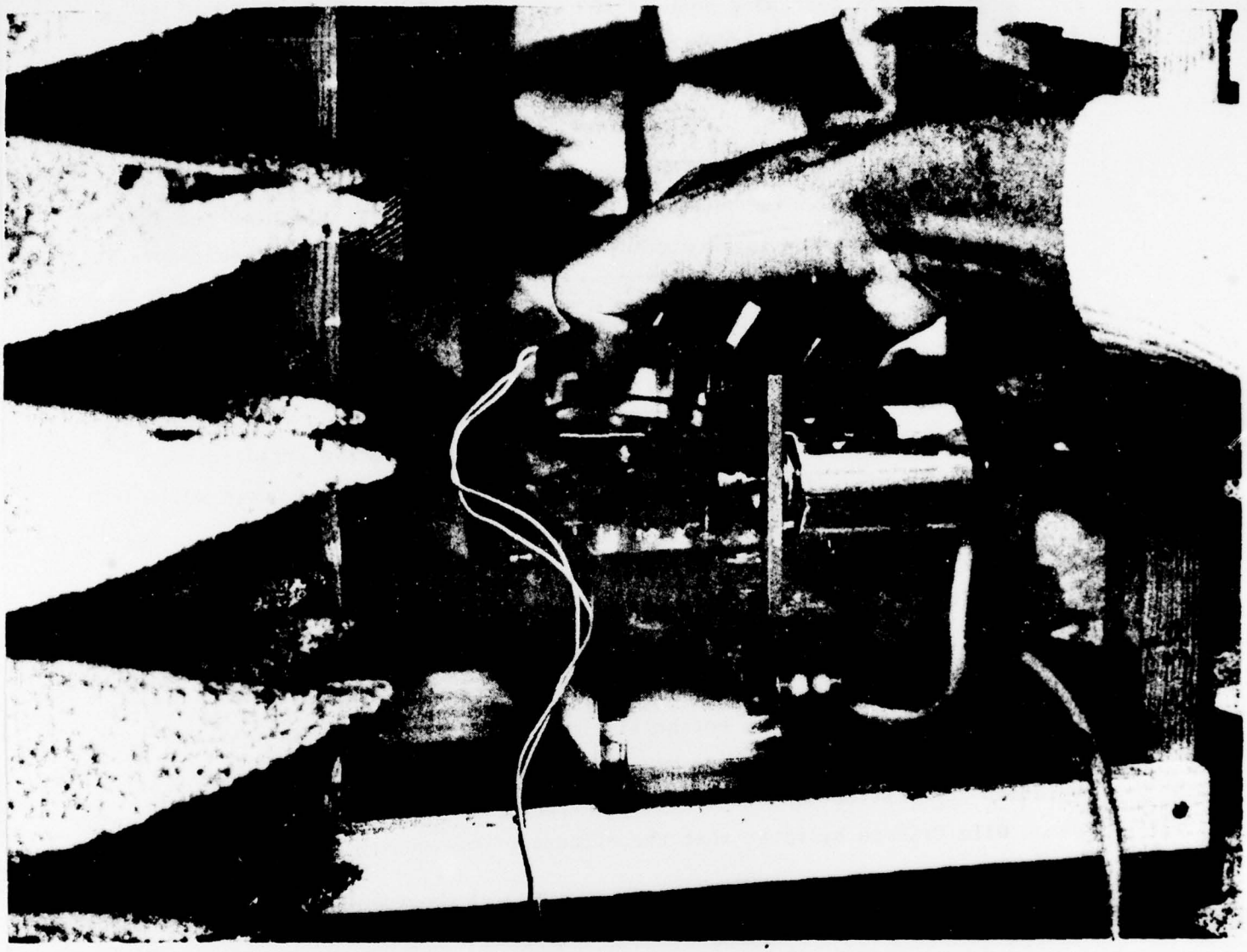

Fig. 1

In order to study the effect of microwave radiation on respiration and tone reaction, the mice were placed in this respiration chamber. This in turn was positioned in a radiation cabinet with an internal covering of microwave absorbing material. In order to obtain various radiation intensities the respiration chamber was placed at various distances from the waveguide outlet in the radiation cabinet.

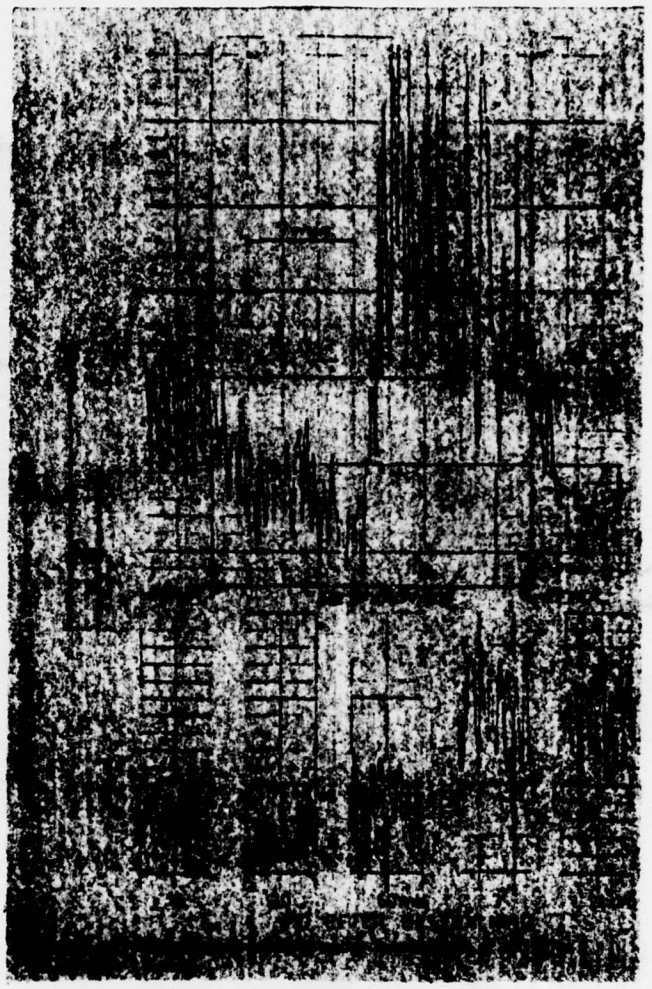

Fig. 2

Example of recording of respiration under tone effect (2,450 MHz, 100 mW/cm^2 for 3 mins.).

Bestrålning, före/efter	=	before/after irradiation
Tid efter bestrålning	=	Time after irradiation
Andningsminutvolym	=	respiratory minute-volume

Fig. 3

Effect on respiration and tone reaction at same dose of microwaves (2,350 MHz) at two differing intensities, 10 and 100 mW/cm^2. Total dose = 300 mW.min/cm^2.

Skillnad i förhållande till kontroll	=	difference in relation to control
Tonreaktion	=	tone reaction
Andningsminutvolym	=	respiratory minute-volume
Min. under bestråln	=	minutes during irradiation

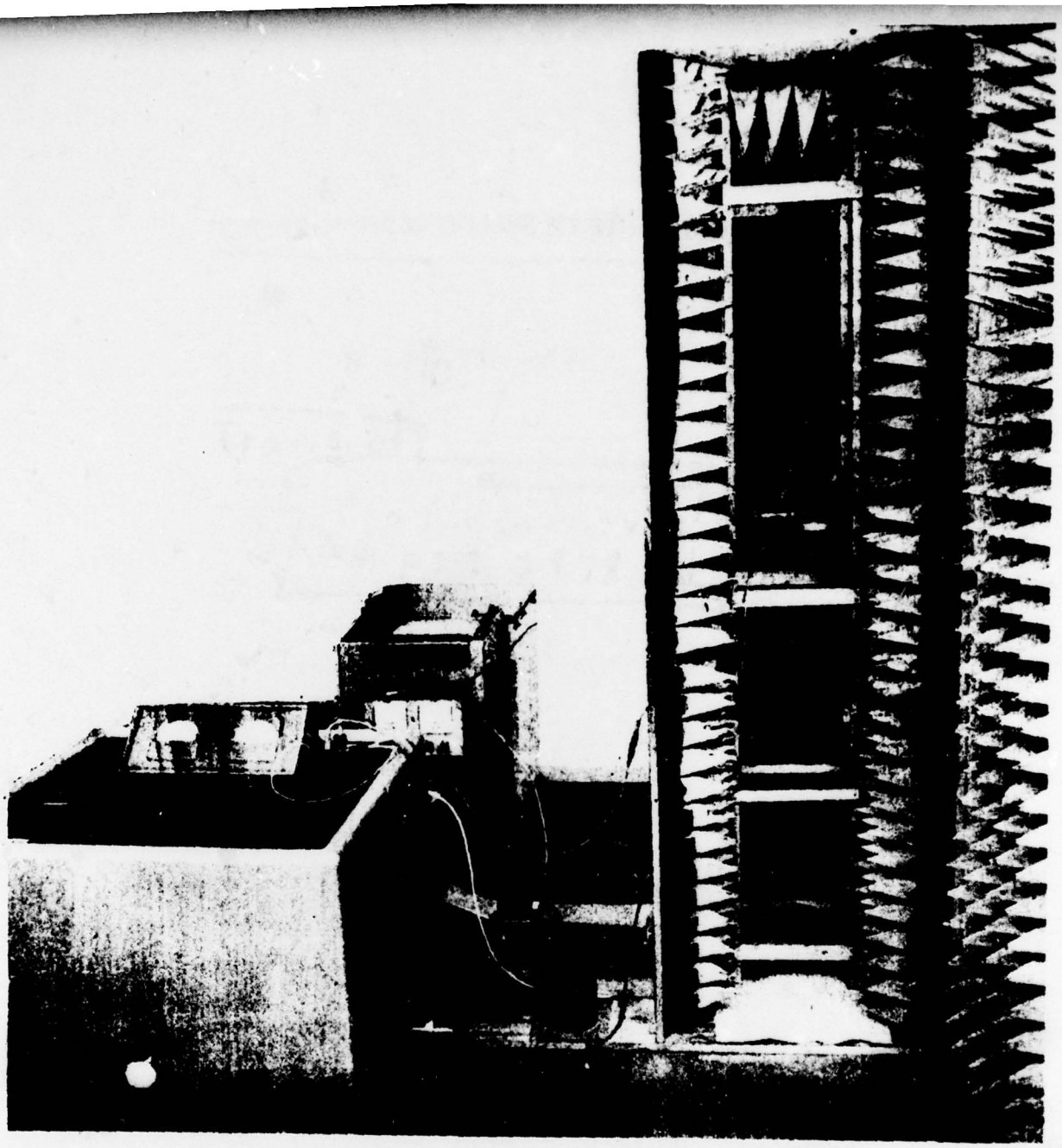

Fig. 4

Test apparatus used in microwave experiments. In the foreground to the left the high voltage unit. Behind this an amplifier for respiration and tone reaction. At back curve-drawing recorder for experimental results. To the right the radiation cabinet with the waveguide outlet in its base. On one of the shelves the respiration chamber with the experimental animal.

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9999000N	FOA TIDNINGEN 16, 3 (1978) 7-9
5a. Sponsoring Agency's Code (if known)	6a. Sponsoring Agency (Contract Authority) Name and Location
7221000N	Procurement Exec., Min. of Defence, Defence Res. Info. Centre, UK.

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ANIMAL EXPERIMENTS AT FOA SHOW THAT MICROWAVES HAVE BOTH PHYSICAL AND PSYCHOLOGICAL EFFECTS

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MIKROVÅGOR PÅVERKAR BÅDE FYSISKT OCH PSYKISKT

7b. Presented at (for conference papers). Title, place and date of conference

8. Author 1, Surname, initials	9a Author 2	9b Authors 3, 4...	10. Date	pp	ref
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11. Contract Number	12. Period	13. Project	14. Other References

15. Distribution statement

Descriptors (or keywords)

Radiation effects, Radiation hazards, Physiological effects, Microwaves, Mice.

Abstract Mice were subjected to radiation intensities of 100, 10 and 1 mW/sq cm for periods of first 6 and later 3 minutes, 6 minutes irradiation at 100 mW/sq cm proving fatal in some cases. Respiration, body temperature, weight and blood haemoglobin were measured, and activity, as shown by running on a wheel, also observed. Immediate effects of exposure were a rise in body temperature and a decrease in respiratory minute-volume. Haemoglobin value and activity on the wheel decreased five days after exposure and returned to normal after 21 days.

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